Measurement of Intake Rate for Sprinkler Irrigation Design

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THE water-intake rate for a soil has to be estimated or measured by the engineer for design of any sprinkler irrigation system. In the past this estimate was usually made by the engineer based on his previous experience. It is now possible to measure the intake rate of water into soil under sprinkler-irrigation conditions using equipment developed by Tovey (1)* and a method developed by Tovey and Pair (2). The intake rate obtained using this method is the maximum that should be used if the sprinkler-design criterion of bringing the soil profile in the root zone of the crop to field capacity without runoff is met. This rate will be referred to in this paper as the "maximum sprinkler-design intake rate."

Measurements of maximum sprinkler-design intake rates were made on several farms in southern Idaho having uniform soils and various crops growing on these soils. Considerable variation in measured maximum sprinkler-design intake rates on the same soil type in various crops on each farm was obtained.

Equipment and Methods

The portable sprinkler-infiltrometer equipment (Fig. 1) included a trailer-mounted water recirculating unit with a sprinkler head operating inside a circular shield and 60 rain gages (1, 2). The trailer-mounted water recirculation system consisted of the following: a 2-ton capacity trailer; a 300-gal water supply tank; two self-priming centrifugal pumps (one with sufficient capacity to deliver at least 100 gpm at 65 psi to the sprinkler nozzles, the other capable of returning all excess water from the shield to the supply tank); flexible intake and discharge hose for both pumps; a pressure gage and four control valves. The screened intake hose and valve arrangement for the main pump made it possible to operate the sprinkler directly from irrigation canals and ditches or to fill the water supply tank when water had to be transported.

Intake-rate measurement sites were located on the dominant soil type of a farm and in most cases where there were two or more crops within 300 ft. Another site selection criterion was the irrigation of the site by the farm sprinkler system within 12 hr or not more than 24 hr previous to the intake-rate measurement so that the soil would be at or near field capacity. If this condition could not be met, then a sprinkler and lawn-sprinkler hose were used to bring the soil to field capacity before making a measurement.

Soil profile charactertistics were observed at each measurement site. Depths of the various soil layers, texture, moisture content, and other special items such as plow pans, lime layers, etc., were noted for future soil correlation.

The equipment was set up with the shield opening in position so that the sprinkler, when operating, covered the site selected for intake rate measurements. The direction of the sprinkler jet was with the wind to give a wider distribution of water-application rates.

After the soil had been brought to near field capacity, three rows of rain gages were set out. These rain gages were spaced at 2½-ft intervals outward from the sprinkler shield. They were located in the center of the wetted area to determine the application rate (2).

The sprinkler was started and run for 1 hr. Water application to the soil was observed and notes made for each row of gages on whether the water was applied too fast, too slow, or was equal to the intake rate. Maximum sprinkler-design intake rate was that rate measured for the gage row where water being applied just disappeared from the soil surface as the sprinkler jet returned to apply more water to the same spot.

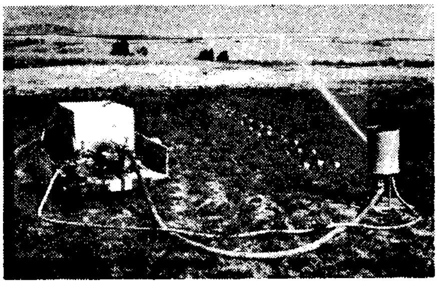

FIG. 1 Sprinkler infiltrometer equipment in operation.

At the end of the test period, the amount of water caught in the various rain gages was measured using a 100-ml graduate. Calculations were then made to determine the application rate in each section of the test area.

Results and Discussion

During 1962-64 maximum sprinkler-design intake rates were measured on farms in the Boise, Twin Falls, and Idaho Falls areas of southern Idaho. The 1962 measurements were on single crops on one soil type per farm. The 1963 and 1964 measurements were made to compare intake rates found on various crops growing on the dominant soil type of a farm.

Results obtained for a farm in the Boise area are shown in Table 1, in the Twin Falls area in Table 2, and in the Idaho Falls area in Table 3. Table 4 shows the results by crops on soils in the various textural classes.

TABLE 1. SPRINKLER IRRIGATION-DESIGN-INTAKE RATES MEASURED FOR VARIOUS CROPS ON A SILT LOAM SOIL* ON THE DALE JONES FARM (E ½, S-10 and NE ½, S-15, T-1-N, R-3-W, Boise meridian)

Crop	Replications	Maximum design intake rate (inches per hour) Average	Standard deviation
Potatoes (bottom of furrow)	6	0.18	0.02
Bare ground	11	.25	.06
Alfalfa	14	.30	.08
Wheat (after harvest)	8	.56	.14

* Classified as Scism silt loam—very deep, calcareous soils having silt loam surface and subsoils with no apparent clay accumulation. The surface is light colored and low to moderately low in organic matter. A strongly calcareous and weakly cemented zone consisting of layers of/or nodules occurs at depths varying from 6 to 12 in.

TABLE 2. SPRINKLER IRRIGATION-DESIGN-INTAKE RATES MEASURED FOR VARIOUS CROPS ON A SANDY LOAM SOIL* ON THE OWYHEE FARMS FARM (SE ¼, S-13, T-90-S, R-27-E, Boise meridian)

Crop	Replications	Maximum design intake rate (inches per hour) Average	Standard deviation
Wheat (emerging from soil)	7	0.33	0.02
Potatoes (bottom of furrow)	3	.46	
Alfalfa	7	.69	.02
Pasture (orchard grass)	16	.79	.04

* Tentatively classified as Keko sandy loam, medium-textured substratum phase—a very deep soil having a fine sandy loam surface and a subsoil of fine silt loam. The surface is light brownish gray and low to moderately low in organic matter. The sandy loam surface layer varies from 19 to 24 in. in depth.

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* Numbers in parentheses refer to the appended references.

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Average maximum sprinkler design-intake rates measured for crops grown in the same soil type varied from 0.18 iph in the bottom of a potato furrow to 0.30 iph for alfalfa and 0.56 iph on wheat stubble on a silt loam soil in southwestern Idaho. In eastern Idaho on another soil classified as a silt loam, the average maximum sprinkler-design intake rate varied from 0.14 iph for potatoes to 0.37 iph for alfalfa. A sandy loam soil in south-central Idaho showed similar variation in maximum sprinkler-design intake rate. The tests showed 0.46 iph for potatoes, 0.69 iph for alfalfa, and 0.79 iph on pasture. Standard deviations listed in Tables 1 through 3 indicate the variability of these soil intake-rate measurements at individual sites.

TABLE 3. SPRINKLER IRRIGATION-DESIGN-INTAKE RATES MEASURED FOR VARIOUS CROPS ON A SILT LOAM SOIL* ON THE NORBERT BRINKMAN FARM (N ½, S-1, T-2-N, R-36-E, Boise meridian)

Crop	Replications	Maximum design intake rate (inches per hour)	
		Average	Standard deviation
Potatoes (bottom of furrow)	5	0.14	0.06
Pasture (grass)	5	.30	.02
Alfalfa	5	.37	.05

* Classified as Portneuf silt loam—very deep soil having a silt loam surface and a fine silt loam subsoil. A slightly compacted layer occurs at the 28 and 34-in. depths on this farm.

TABLE 4. SPRINKLER IRRIGATION-DESIGN-INTAKE RATES FOR VARIOUS CROPS AND SOILS AT DIFFERENT LOCATIONS

Crop	Maximum design intake rates (inches per hour)	
	Silt loam soils	Sandy loam soils
Alfalfa	0.17	0.24
	.23	.30
	.24	.69
	.30	
	.37	
	.45	
Potatoes	0.12	0.18
	.14	.46
	.18	
	.21	
Sugar beets	0.13	0.18
Wheat	0.56 (stubble)	0.33 (emerging)
Pasture	0.30	0.79
Peas		0.49
Corn		0.24
Bare ground	0.14	
	0.25	

Table 4 shows the results obtained from a number of individual intake determinations in southern Idaho and are given to show the range of intake rates for crops on soils classified as silt loams and sandy loams.

One reason for the variation of sprinkler-design intake rates measured on all soils is the wide range of soil types combined into these classifications. Another cause of the variation in rates is the amount of compaction from farm tractors and other machinery while preparing the seedbed, planting and cultivating the row crops. A factor in the intake rate variation for various crops on the same soil type was the amount of crop residue on the surface soil at the measurement site.

The intake rates obtained show that the designer of sprinkler systems should consider the cropping pattern followed by the farm management as well as the soil-type map when selecting a design water-application rate for a farm.

It should be stressed that the sprinkler design-intake rates reported are the maximum rates at which water can b applied to the soil without runoff. I field practice the water-application rate should be less than the maximum sprinkler design-intake rate as long as it exceeds the evaporation rate in the area. Within this range of application rates the sprinkler-system designer can select a sprinkler that will give good water distribution and an operating time satisfactory for the equipment and labor available.

Conclusion

Equipment and a method are available for measuring the maximum water-intake rate for sprinkler design. The magnitude of sprinkler-design intake rates measured for several crops on a single soil type varied as much as 100 percent. The lowest rates were usually measured in the furrow on row crops where the soil had been worked many times with farm tractors and other farm equipment in the seedbed preparation, planting, cultivating and spraying of the crop.

References

1 Tovey, Rhys. A portable irrigation sprinkler evaluation device. Irrigation Engineering and Maintenance 12:(2)8-9, 1962. Agricultural Engineering 44:(12)672-673, December 1963.

2 Tovey, Rhys and Pair, C. H. A method measuring intake rate into soil for sprinkler c sign. Proc. of Natl. Sprinkler Irrign. Assn., tech nical conference, March 1963.